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# High-level Strata Containing Early Miocene Mammals on the Bighorn Mountains, Wyoming

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## ABSTRACT

Fossil mammals of early Miocene age have been found in strata composing Darton's Bluff on the crest of the Bighorn Mountains in the Hazelton Peak Quadrangle, Johnson County, Wyoming. Dating the host strata provides a reference datum for the reconstruction of regional sedimentation during early Miocene time and for determination of the maximum age of epeirogenic uplift. As a result of regional aggradation, the Bighorn Basin was filled with sediments. These buried the rugged peaks and canyons of the Bighorn Mountains up to a level corresponding to the present 9000-foot altitude during early Miocene time. The lower Miocene and older rocks are beveled by the subsummit surface, a remarkably flat and even surface of Miocene or Pliocene age. Excavation of the Bighorn and Powder River basins and exhumation of the Bighorn Mountains must have been accomplished during the relatively short interval of late Cenozoic time after the subsummit surface was cut.

## INTRODUCTION

Darton (1906) described and mapped several occurrences of essentially flat-lying Cenozoic strata at altitudes of about 9000 feet; these strata rest on a surface of high to moderate relief, cut in the Precambrian and

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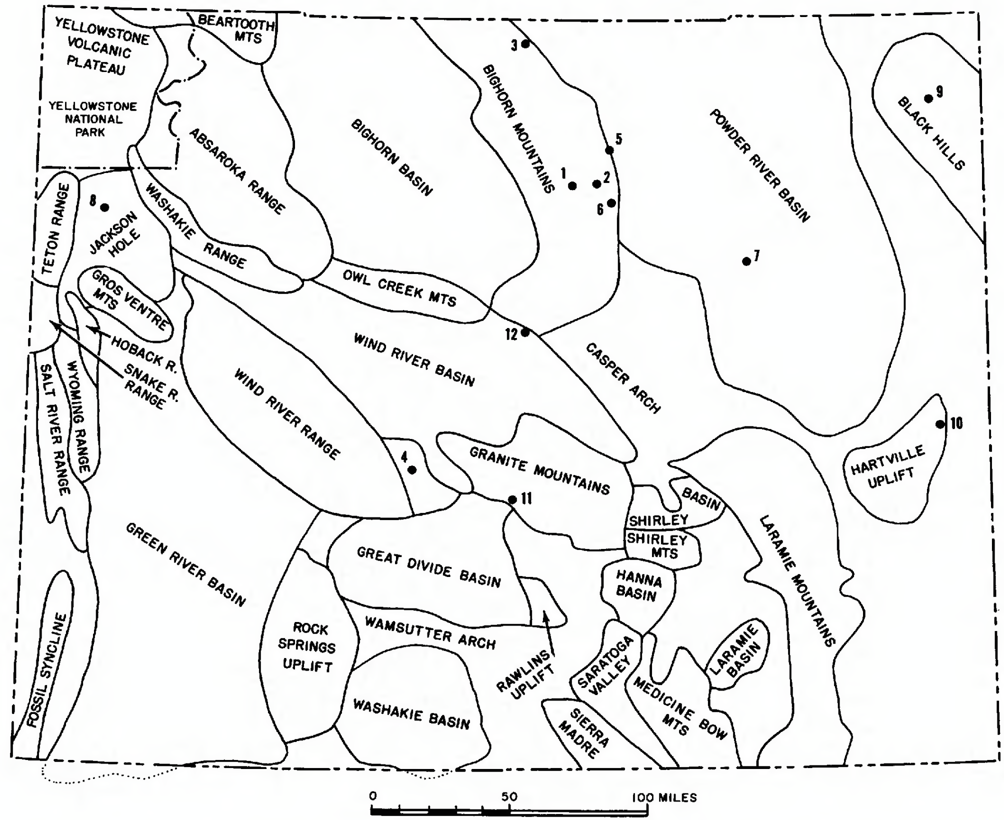



FIG. 1. Map of Wyoming showing localities numbered 1–12 discussed in the text and their relation to major mountains, basins, and volcanic areas. Darton's Bluff is locality 1.

Paleozoic core of the Bighorn Mountains, Wyoming. He published photographs (1906, pl. 22), a reconnaissance stratigraphic section, and a description of one of the thickest sections exposed along a bluff near the head of Canyon Creek in sect. 19, T. 48 N., R. 85 W., Hazelton Peak Quadrangle, Johnson County (Darton, 1906, p. 67). This site is known to geologists as Darton's Bluff (fig. 1, loc. 1; Miocene rocks at fig. 2B, loc. D). About 10 miles farther east (fig. 1, loc. 2) are broad exposures of different-appearing light-colored claystones containing limy concretions and some boulder conglomerates. Concerning this latter sequence, Darton commented (1906, p. 68): "It is similar in appearance to some of the Oligocene deposits in the Black Hills, so it is provisionally correlated with them."

The first vertebrate fossil reported from any of these high-level deposits on the Bighorn Mountains was found by Osterwald (1949, p. 37; 1959, p. 30) about 55 miles northwest of Darton's Bluff along the northern crest of the uplift in the SE. ¼, SW. ¼, sect. 5, T. 56 N., R. 88 W., (fig. 1, loc. 3; fig. 2A, loc. C). This fossil, identified by P. O. McGrew as a medial phalanx of *Mesohippus*, was considered to be of Oligocene age. Recently a fragmentary skeleton, identified as *Hoplophoneus* by W. D. Turnbull of the Field Museum of Natural History, was collected at the same locality by members of the Geology Department, University of Illinois, Urbana. This specimen, whose identification confirms the Oligocene age of the deposits containing it, is now housed in the Field Museum of Natural History.

Studies of the Darton's Bluff section by Love in 1950 and 1951 (1952, 1954) suggested that the Darton's Bluff strata might be of Miocene rather than Oligocene age. Van Houten (1952, pp. 77–79) compared shards and heavy minerals from this section with those of vertebrate-bearing Miocene rocks in the Beaver Divide area of central Wyoming (fig. 1, loc. 4) and concluded that the features of the middle part of the Darton's Bluff outcrop "point to correlation with Miocene deposits of the Plains and Beaver Divide region. . . . "

Boulder beds about 20 miles northeast of Darton's Bluff were described and mapped by Mapel (1959) and by Nelson (1968) as Oligocene or Oligocene(?) (fig. 1, loc. 5). Hose (1955, pp. 70–71, 88) discussed light-colored bentonitic manganese-bearing claystones and conglomerates from a locality 15 miles southeast of Darton's Bluff (fig. 1, loc. 6; Oligocene rocks near loc. D, fig. 2B) as White River Formation. A tooth of *Mesohippus* and fragmentary titanothere remains have been recovered from these deposits and are housed in the Field Museum of Natural History. Chadronian (early Oligocene) age is indicated for the enclosing

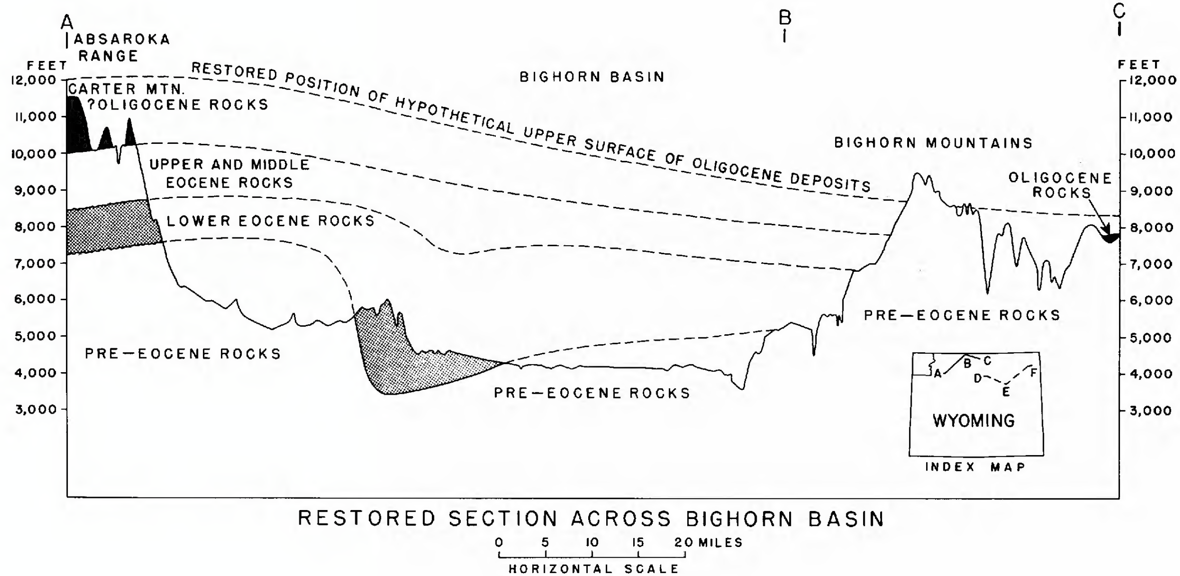



FIG. 2A. Restored section of Eocene and Oligocene rocks across the Bighorn Basin showing possible crustal rebound after excavation in late Cenozoic time.

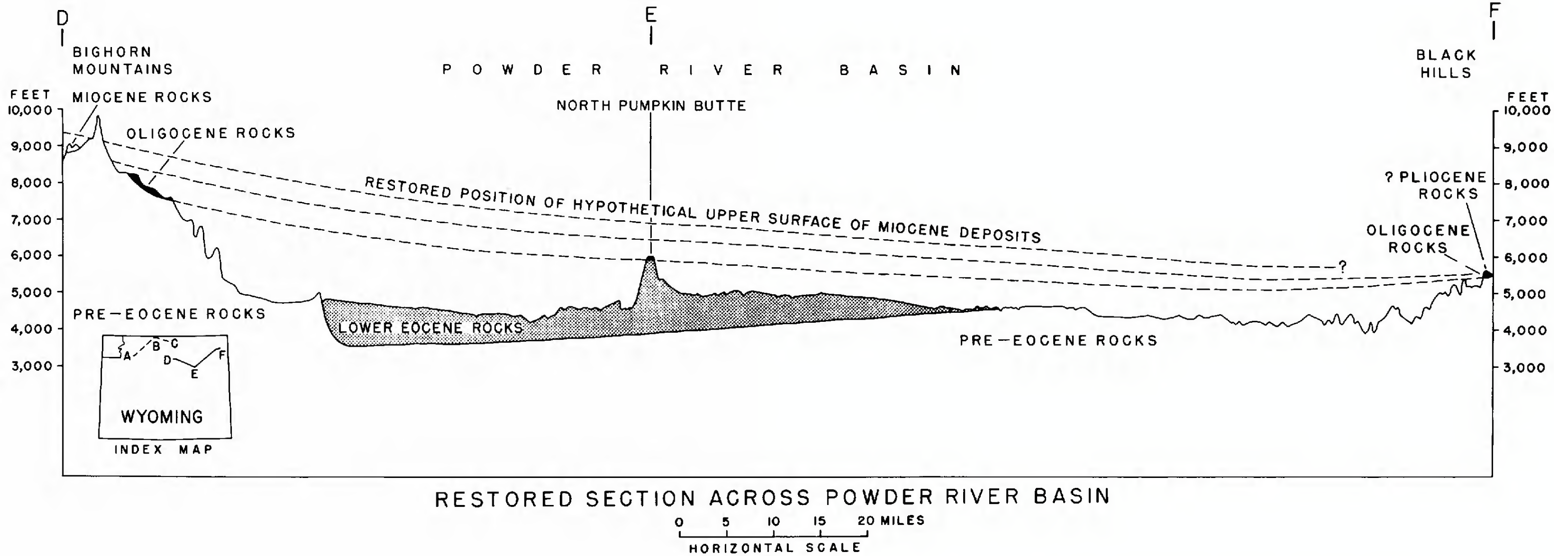



FIG. 2B. Restored section of Wyoming of Eocene, Oligocene, and Miocene rocks across the Powder River Basin.

sediments. Oligocene fossils were found in the caprock on Pumpkin Buttes, in the middle of the Powder River Basin, 65 miles southeast of Darton's Bluff (Love, 1952, 1954; present report, fig. 1, loc. 7; fig. 2B, loc. E). The Pumpkin Buttes occurrence provides much-needed control on the Oligocene fill that originally extended from the Bighorn Mountains southeastward across the Powder River Basin.

On the geologic map of Wyoming (Love, Weitz, and Hose, 1955), Darton's Bluff and a few other localities were shown as Miocene and Oligocene rocks, undivided, and the remaining high-level remnants were called White River Formation.

An attempt to date, by paleontological means, as many as possible of the high-level Tertiary deposits on the Bighorn Mountains was begun by personnel of the American Museum of Natural History in 1962 and was continued through 1970. This search was rewarded by the discovery of an assemblage of early Miocene (early Arikareean) fossil mammals in the exposures of Darton's Bluff (McKenna, 1968).

## Acknowledgments

All the Miocene fossils described in the present report are the result of dedicated efforts for the American Museum of Natural History by Mr. Wesley Gordon of Hayward, California, and his associates. The variety and high quality of the remains collected represent diligence on their part over many years of difficult prospecting rather than an abundance of fossils at the outcrops. Drawings were prepared by Dr. Dale A. Russell and Mrs. Patricia Robinson. The oblique air photograph was obtained with the generous aid of Mr. Ronald H. Gordon, who provided his aircraft, Hasselblad camera, and skills at photographic development. Mr. Beryl Taylor and Mrs. Margaret S. Stevens provided much helpful information regarding the Miocene fossils. We are indebted to Dr. W. Hilton Johnson of the Geology Department, University of Illinois at Urbana, for information concerning collections including Oligocene fossils from various localities in the Bighorn Mountains. Permission to work in the Bighorn National Forest was granted by Mr. David S. Johns, Forest Supervisor.

## Abbreviations

AC, Amherst College Museum
AMNH, Department of Vertebrate Paleontology, the American Museum of Natural History
MCZ, Museum of Comparative Zoology, Harvard University
YPM, Peabody Museum of Natural History, Yale University
Wyo, Thin section collection, United States Geological Survey office, University of Wyoming

## STRATIGRAPHIC SIGNIFICANCE OF LOWER MIOCENE ROCKS AND FOSSILS AT DARTON'S BLUFF LOCALITY

We consider the discovery of fossil mammals of early Miocene age on the crest of the Bighorns, a major mountain range flanked on the east and west sides by major intermontane basins (fig. 1), to be especially significant because these fossils provide data on the mid-Tertiary environment and general altitude of the land surface, permitting comparison with the environment of the High Plains of western Nebraska where vertebrate fossils of the same age are abundant. The Darton's Bluff fossil vertebrates collected thus far are essentially the same as those of the High Plains.

The dating of the strata at Darton's Bluff provides a reference point for the reconstruction of the history of regional sedimentation during early Miocene time. The paucity of both regional and local data on Miocene rocks is demonstrated by the following brief review. Darton's Bluff is the only control point in all the northern half of Wyoming east of the 7000-foot-thick lower(?) and middle Miocene Colter Formation (Love, 1956; Black, 1968) of Teton County (fig. 1, loc. 8), about 170 miles to the west. The only fossiliferous post-Oligocene rocks in northeastern Wyoming are a thin remnant of "Ogallala Formation" near the Bear Lodge Mountains in the northwestern Black Hills (fig. 1, loc. 9; fig. 2B, loc. F). These rocks were thought by Brown (MS) to be Pliocene on the basis of the seed *Biorbia fossilia*. If, indeed, they are Pliocene, the nearest Miocene rocks northeast of Darton's Bluff are in the Short Pine Hills of western South Dakota and the Long Pine Hills of southeastern Montana (Wood, 1945; Denson, Bachman, and Zeller, 1959, fig. 5), both about 175 miles northeast of the Bighorn Mountains.

Fossiliferous lower Miocene rocks at present between 4000 and 5000 feet above sea level are known near Drummond and Deer Lodge, Montana, about 325 miles northwest of Darton's Bluff; near Fort Logan, Montana, 260 miles to the northwest; and at a scattering of poorly known localities in southwestern Montana at somewhat higher altitudes, about 235 miles to the west-northwest of Darton's Bluff, beyond Yellowstone Park.

Miocene rocks are extensively exposed along parts of the southern and southeastern margins of the Powder River Basin (fig. 1), around the Hartville uplift (fig. 1, loc. 10), 130–150 miles southeast of Darton's Bluff, along the Beaver Divide in central Wyoming (present report, fig. 1, loc. 4; Van Houten, 1964), and in the Split Rock area (present report, fig. 1, loc. 11; Love, 1970), 100–125 miles to the southwest.

A downfaulted remnant of possible Miocene rocks is present in the Badwater area (fig. 1, loc. 12) at the southern end of the Bighorn Moun-

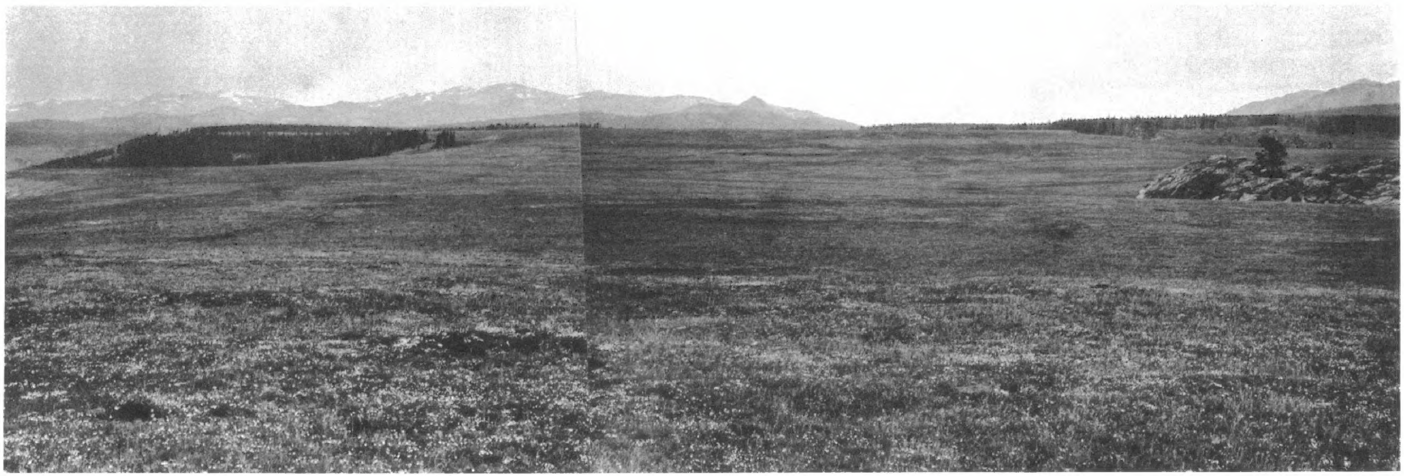


FIG. 3. Subsummit surface that bevels Miocene and older rocks at an elevation of about 9000 feet along the watershed divide of the Bighorn Mountains. View is north-northeast. Darton's Bluff is in middle distance at left. Photograph by N. H. Darton, about 1904.

tains, 56 miles south-southwest of Darton's Bluff. The stratigraphy and fossils at the Badwater locality have been described by Black (1969) who considered the basal part to be youngest Oligocene in age on the basis of vertebrate fossils. The overlying 700 feet or more of strata have not yielded diagnostic fossils as yet but the lithology is strikingly similar to that of the lower Miocene rocks at Darton's Bluff. It seems likely, therefore, that in the Badwater area deposition was nearly continuous from Oligocene into early Miocene time.

The dated Miocene rocks at Darton's Bluff provide paleontologic evidence that confirms the concept that regional aggradation during early Miocene time filled the Bighorn Basin with sediment and buried the rugged peaks and canyons of the Bighorn Mountains up to a level corresponding to the present 9000-foot altitude. Thus, at that time, at least part of the vast flood of volcanic-rich sediment that spread eastward across central and eastern Wyoming from vents in the Jackson Hole-Yellowstone-Absaroka region, and possibly from other sources farther west and southwest, extended this far north. Sedimentation continued, with interruptions, until Pliocene time in other parts of Wyoming (Love, 1960, 1970), but direct evidence for the maximum depth of burial and the end of deposition in the Bighorn Mountains is lacking, because no post-Arikareean Tertiary deposits have yet been identified there. If they were ever present, they probably were stripped away at the time of development of the subsummit surface (Alden, 1924).

The subsummit surface (fig. 3) is a remarkably flat and even surface that bevels lower Miocene and older rocks. Alden (1924, pp. 395–396) considered the surface to be Oligocene or Miocene. Others thought it might be more logically of Pliocene age (Bevan, 1925, p. 580; Mackin, 1937, 1947; Love, 1939, 1960). Because the surface cuts across hard Precambrian rocks as well as soft lower Miocene strata, it presumably was not developed rapidly. Excavation of the Bighorn and Powder River basins and exhumation of the Bighorn Mountains must have been accomplished largely after the surface was cut and therefore must have taken place during a relatively short interval of late Cenozoic time.

When one attempts to reconstruct the thickness of Tertiary fill in the Bighorn and Powder River basins (fig. 2) and to fit the Cenozoic history into a regional framework, several provocative questions arise: (a) To what degree did the weight of 9000 feet or more of post-Paleocene rocks depress the Bighorn Basin? (b) After the rapid late Cenozoic removal of most of this fill, how much did the crust underlying the basin rebound? (c) Can the removal of a relatively finite volume of rock from these various basins in a short interval of time be used as a valid example of the rate of

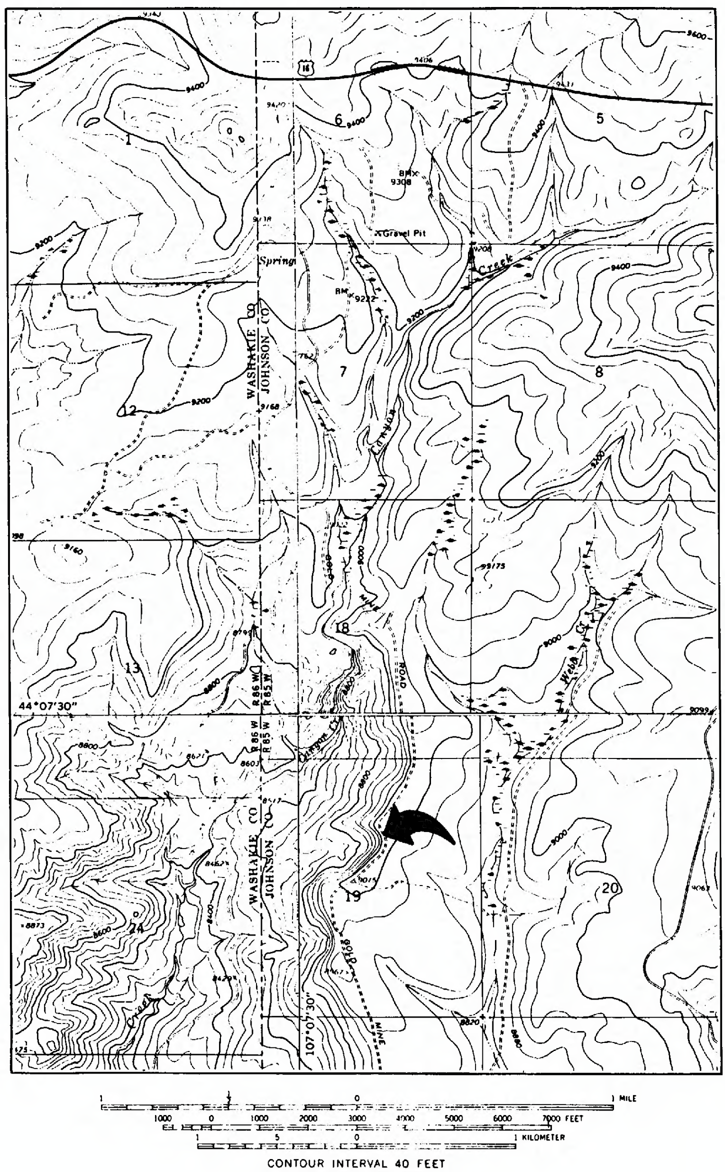



Fig. 4. Map showing location of Darton's Bluff. Base from U. S. Geological Survey uncorrected advance sheets of Powder River Pass, Onion Gulch, Hazelton Peak, and Meadowlark Lake quadrangles, 1967. Arrow points to Darton's Bluff.

intermontane degradation in late Cenozoic time? (d) Where was base level when the basins were being excavated, and what happened to the debris downstream? (e) What climatic inferences can be drawn (certainly,

FIG. 5. Oblique aerial view east-southeast showing Miocene white strata exposed in Darton's Bluff in foreground, beveled by the bare, grassy subsummit surface. Hazelton Peak, composed of Precambrian rocks, is on center skyline. Photograph by M. C. McKenna, July 23, 1970.

a large volume of water moving with considerable velocity was needed for basin excavation)? (f) What was the effect of epeirogenic uplift on excavation of the basins and exhumation of the Bighorn Mountains? (g) Can we infer that the effect of epeirogenic uplift was not significant in this area until after the subsummit surface was cut?

As is suggested in figure 2A, isostatic rebound in the Bighorn Basin may have been considerable. In the Powder River Basin, however, where the post-Paleocene fill was not so thick (fig. 2B), rebound is not so evident. More definitive answers to these and the other questions must await the acquisition of additional regional data of many types. It is hoped that the regional implications of the Darton's Bluff site will encourage other investigators to attempt similar studies of isolated remnants of high-level Tertiary deposits. Ultimately, such studies will provide reasonable answers to the questions propounded here and will contribute to an appreciation of the complex Cenozoic history of the region.

FIG. 6. View southeast at upper part of section on Darton's Bluff. Light-colored beds at lower right are sandstones in unit 8. Dark beds near top are arkosic conglomerates in unit 14. Smooth slope capped by vertical bank at top left is unit 15. Compare this photograph with that by Darton (1906, pl. 22A) taken about 1904. Photograph by J. D. Love, October 23, 1950.

## MID-TERTIARY FOSSIL OCCURRENCES ON THE BIGHORN MOUNTAINS

The following fossils were found or have been reported from high-level mid-Tertiary deposits on the Bighorn Mountains:

1. A toe bone in the University of Wyoming collections of a *Mesohippus*-like horse, and a partial skeleton identified as *Hoplophoneus* by W. D. Turnbull, Field Museum of Natural History, SW. 1/4, sect. 5, T. 56 N., R. 88 W., (fig. 1, loc. 3). Additional fragments of bones from this area have been found during our field work, but none has been biostratigraphically useful.
2. Southeast side of U. S. Highway 16, about one-fourth mile southwest of Pines Resort, SE. corner sect. 15, T. 50 N., R. 84 W., at approximate altitude of 7555 feet above sea level; estimated 55 feet of brown claystone containing teeth and bone fragments of Oligocene aspect (lost).
3. Unidentified snail in limy layer, road cut in sect. 36, T. 49 N., R. 84 W.
4. Tooth of *Mesohippus* and titanothere tooth and bone fragments, NE. 1/4, sect. 14, T. 46 N., R. 85 W., near Pass Creek. Chadronian. Identification by John Clark, Field Museum of Natural History.
5. Subterminal phalanx of *Mesohippus*(?), an artiodactyl astragalus, and other bone scrap, sect. 18, T. 48 N., R. 85 W. "About 1/2 mile north of the large Canyon Creek section [W. Hilton Johnson, personal commun.]." Identification by W. D. Turnbull, Field Museum of Natural History.
6. Darton's Bluff locality (fig. 4), SW. 1/4, NE. 1/4, sect. 19, T. 48 N., R. 85 W. Detailed description of the stratigraphy and a Miocene fauna at this locality follows.

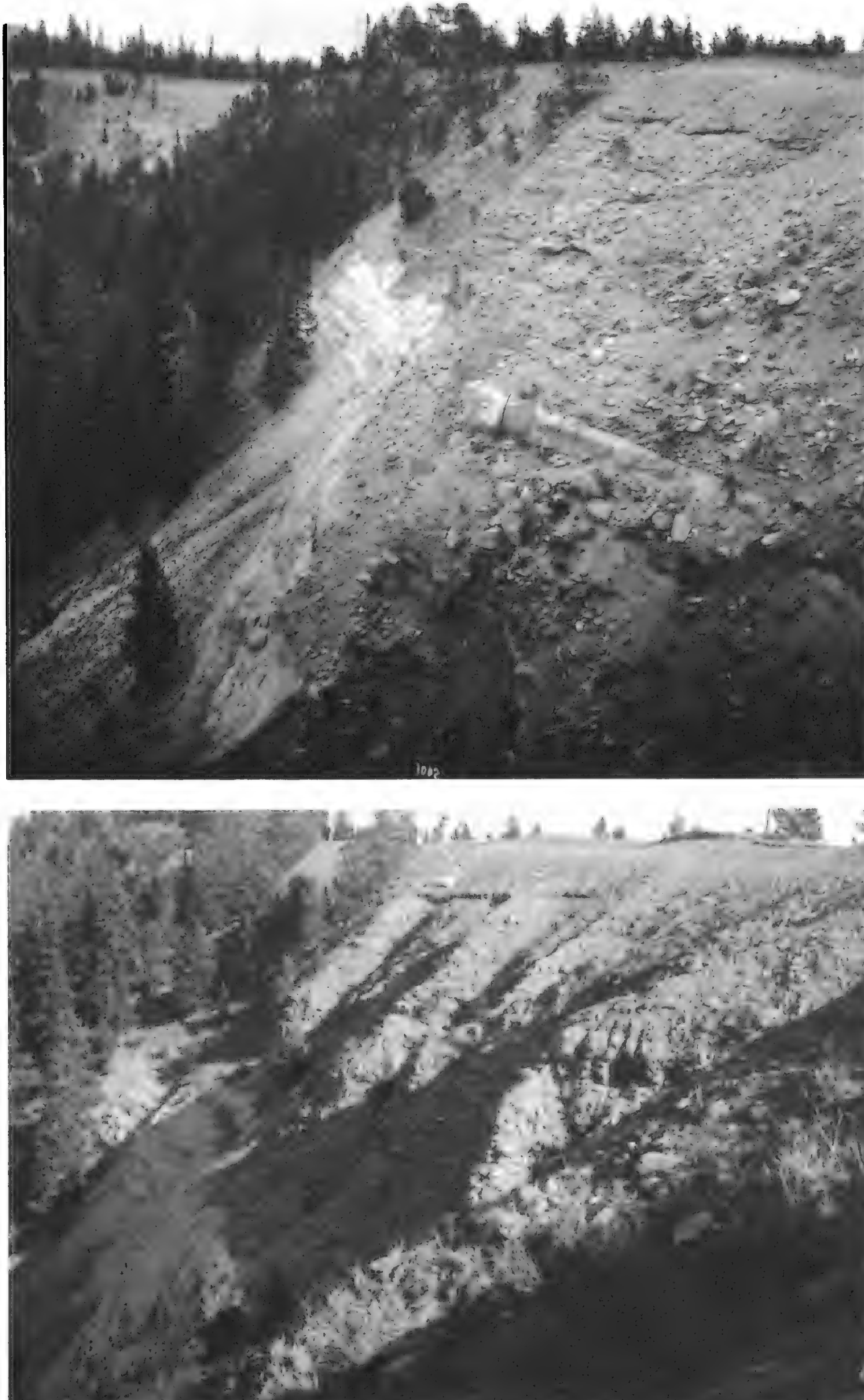
FIG. 7. Close view of massive shard-rich sandstone in unit 8 of measured section. Photograph by J. D. Love, October 23, 1950.

## STRATIGRAPHY OF DARTON'S BLUFF LOCALITY

Figures 4 and 5 show the general setting of the Darton's Bluff locality and figures 6, 7, and 8 illustrate the physical appearance of various units described in the measured section.

## DARTON'S BLUFF SECTION OF MIOCENE AND ASSOCIATED STRATA

The following section was measured with hand level and steel tape by Love, October 13, 1951, on the west face of Darton's Bluff, near the center of sect. 19, T. 48 N., R. 85 W., Hazelton Peak Quadrangle, Johnson County, Wyoming. This is believed to be the site of a section measured by E. S. Bastin, quoted and illustrated by Darton (1906, p. 67, and pl. 22). The Miocene rocks at Darton's Bluff are not faulted and appear to be essentially horizontal.



A

B

FIG. 8. Upper conglomerate and lens of tan sandstone in unit 14 at right. Massive sandstone of unit 8 is at lower left. A. Photograph by N. H. Darton (1906, pl. 22B), taken about 1904. B. Photograph by J. D. Love, October 23, 1950.

| | Thickness (feet) |
|---|---|
| Deposits of unknown age: | |
| 15. Loesslike soil, dark grayish brown, chiefly silt with numerous fine to medium sand grains; some carbonaceous layers; some vertical fracturing near top; more massive in lower part; top of unit is top of remarkably flat surface at 9000 feet (see uppermost exposures in fig. 6) | 8 |

Contact between deposits of unknown age and Miocene rocks, very sharp and even.

| | Thickness (feet) |
|---|---|
| Miocene rocks: | |
| 14. Arkosic conglomerate, brown, very soft; forms slope littered with boulders of granite, black gneiss, and schist of various sizes and shapes, as much as 4 feet in diameter; some much decayed and others fresh; top 4 feet very soft arkose with a few boulders; about 300 feet southwest of the main exposure and 10 feet below top of unit is a 5-foot lens of soft massive, tan, medium-grained to coarse-grained sandstone; lens is shown in Darton's (1906) photograph, plate 22B (fig. 8) | 30 |
| 13. Sandstone, tan, soft, massive, fine-grained, with numerous larger grains; not so homogeneous as unit 8; forming highest bulbous ledge in the escarpment (fig. 6) | 4 |
| 12. Conglomerate, gray, arkosic, bedded, very soft; contains angular to subrounded boulders as much as 2 feet in diameter of granite, schist, and gneiss; no tuffaceous matrix observed | 7 |
| 11. Sandstone, tan, clean, massive, soft; coarse-grained with a great variety of mineral grains; forms bulbous ledge | 2 |
| 10. Sandstone, light buff to gray, coarser-grained and not so homogeneous as unit 8; some pebbles of Precambrian rocks near top | 11 |
| 9. Siltstone, mouse gray, blocky, soft; forms reentrant in cliff | 1.5 |
| 8. Sandstone, light buff to tan in lower part, becoming light gray in upper; almost completely massive, homogeneous, soft, porous, fine-grained; abundant black and red grains; upper 10 feet forms cliff; unit composes main bare light-colored fluted slope shown in Darton's photographs and in figures 6 and 7 (present report); thin section Wyo 426 contains about 60 per cent glass shards, andesite rock fragments, pyroxene, amphibole, and biotite; yielded all early Miocene fossil vertebrates described in present report | 72 |
| 7. Sandstone and conglomerate composed of angular fragments of black schist and gneiss embedded in a marly gray sandstone matrix; conglomerate beds intertongue with sandstone beds; a very irregular unit that is about 30 per cent conglomerate | 10 |
| 6. Conglomerate, gray, composed of a variety of angular to subrounded black schist and gneiss and pink granite fragments embedded in a gray marly matrix | 4 |
| Total thickness of Miocene rocks | 141.5 |

Miocene and Oligocene(?) rocks:

5. Limestone, white to light gray, hard; forms conspicuous massive ledge; sparse red grains and some black grains; local concentrations of euhe-

| | | |
|---|---|---|
| | dral biotite; a very irregular bed . . . . . . . . . . . . . . . . | 4 |
| 4. | Conglomerate, gray, with angular to rounded fragments of decayed to fresh black schist and gneiss as much as 2 feet but averaging 6 inches in maximum dimension, embedded in white limestone matrix; granite fragments are fresh . . . . . . . . . . . . . . . . . . . . . . | 6 |
| 3. | Limestone, white, fine grained, hard; looks fibrous in part (like hot-spring deposit); thin section Wyo 755 is entirely carbonate rock . . | 3 |
| 2. | Covered interval; unit appears soft and may contain some plastic claystone which is suggestive of Oligocene rocks . . . . . . . . . . . | 25 |
| | Total thickness of Miocene and Oligocene(?) rocks . . . . . . . . | 38 |

Approximate contact between Miocene or Oligocene(?) and Precambrian rocks.

Precambrian rocks:

1. Schist, black, foliated, and black layered gneiss

Units 2 to 5 are lithologically distinct from the overlying conglomerate and from the tuffaceous sandstone that contains Miocene fossils and they possibly may be of Oligocene age. A similar-appearing white limestone is associated with bentonitic plastic claystone near locality 5 (fig. 1). This claystone is lithologically like that called White River at locality 6 (present report, fig. 1; Hose, 1955, pp. 70–71, 88). This reasoning is only suggestive but when the stratigraphy and faunas of Oligocene rocks on the Bighorn Mountains are better known, these comparisons may become meaningful.

## Vertebrate Fossil Assemblage at Darton's Bluff

All vertebrate fossils were collected from unit 8 in the measured section. They are of early Miocene age and are approximately contemporaneous with those in the lower part of the Arikaree Group of eastern Wyoming, Nebraska, and South Dakota. They are older than all but one (*Merycoides cursor*) of the vertebrate fossils from the Split Rock Formation (Love, 1970) in south-central Wyoming (in part the Arikaree Formation as extended by Denson, 1965, p. A71). The Darton's Bluff local fauna (new local fauna) is slightly older than the lower vertebrate assemblage in the Colter Formation of Jackson Hole (present report, fig. 1; Black, 1968).

## ORDER INSECTIVORA

### FAMILY TALPIDAE

#### SUBFAMILY PROSCALOPINAE

#### *Proscalops* cf. *P. secundus* Matthew, 1909

Material: AMNH 56339, fragmentary right front leg.

Comments: A disarticulated but nevertheless closely associated trio

of fragmentary bones from the right front leg of a proscalopine mole ("*Arctoryctes*") was recovered. The distal half of the right humerus is present, although the teres tubercle is broken away. Present also is the proximal end of the right radius, with its characteristic articulations for both the capitulum and the lateral epicondyle of the humerus. The right ulna is represented by the olecranon process, semilunar notch, radial articulation facet, posterior crest, and pit for the probable origin of M. abductor pollicis longus. From the lateral edge of the capitulum to the medial edge of the fossa for the origin of the great ligament of M. flexor digitorum profundus the distance is 7.7 mm. (See Reed and Turnbull, 1965, p. 166).

Unfortunately, no trace of the dentition was found, but the close association of the three bones recovered confirms the synthesis of Reed and Turnbull (1965) that these peculiar arm bones belong to a single taxon. The bones can be articulated and they fit perfectly. A fourth fragment of bone, found about an inch away in the matrix, may represent the same animal. It may belong to the clavicle, at present undescribed in proscalopines.

## ORDER LAGOMORPHA

### FAMILY OCHOTONIDAE

#### *Desmatolagus* sp.

MATERIAL: AMNH 56336.

COMMENTS: A poorly preserved maxilla of this ochotonid is present. The known range of the genus is from Oligocene to early Miocene in Asia and North America.

## ORDER RODENTIA

### FAMILY GEOMYIDAE

#### *Entoptychus* sp.

Figures 9, 10

MATERIAL: AMNH 56331, left $M^1$–$M^3$, and AMNH 56332, right lower jaw with I, $P_4$–$M_3$.

COMMENTS: The taxonomy of this genus of geomyid is chaotic currently, but comparisons with species from the Harrison Formation of the High Plains and from part of the John Day Formation in Oregon are favorable. Until a revision of the genus is accomplished based upon a thorough knowledge of the effects of wear upon tooth measurements, no "new" taxa should be named. Evidently the teeth of the species from Darton's

Bluff were very high crowned, with deep valleys between the lophs and lophids. A trace of an anterolophid may be seen on $P_4$ of AMNH 56332. $M^1$–$M^3$ measure 5.1 mm. in combined anteroposterior length at the level of the occlusal surfaces, and a similar measurement for $P_4$–$M_3$ gives 7 mm. These figures would, of course, change with either more or less wear. The

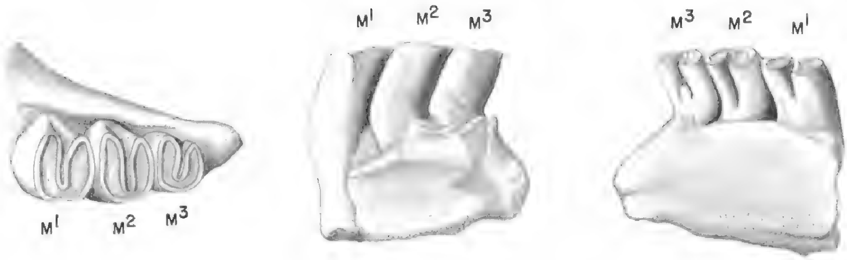



FIG. 9. *Entoptychus* sp., AMNH 56331, left maxillary fragment with $M^1$-$M^3$. Left, occlusal view; center, lingual view (inverted); right, buccal view. All ×4.0.

lower incisor has orange enamel and a flat face without grooves. At the tip at its present level of wear the enamel face of the incisor is 2.2 mm. wide.

### *Pleurolicus* cf. *P. leptophrys* Cope, 1881

Figures 11–13

MATERIAL: AMNH 56330, right lower jaw fragment with $P_4$–$M_2$, and AMNH 56334, left maxillary fragment with $P^4$–$M^3$.

COMMENTS: Small individuals of *Pleurolicus* similar to *Pleurolicus leptophrys* Cope, 1881, are represented by two specimens which average about 83 per cent of the size of AMNH 7185 and 7158, referred specimens, from unspecified levels in the John Day Formation in Oregon. All the teeth from Darton's Bluff have enamel that terminates before the alveolus is reached. The roots are divided and clearly visible, and the crowns are relatively lower than in other entoptychine genera. $P^4$–$M^3$ all have essentially the same "U"-shaped pattern with a shallow valley opening to the buccal side of the tooth. Wear has obliterated the original cusp apexes, so that it is not possible to state, for instance, whether $P^4$ had a single-cusped protoloph or a three-cusped metaloph (see Wood, 1936, p. 5). Unworn material would be necessary to determine those features. $P^4$ evidently lacked an anterior cingulum. $P^4$–$M^3$ length at the level of the present occlusal surface is 4.95 mm. $P_4$ has only two anterior cusps, behind which a deep pocket is enclosed. The molars have a trace of an "H" pattern (cf. Wood, 1936, p.7) caused by an angulation on the rear enamel

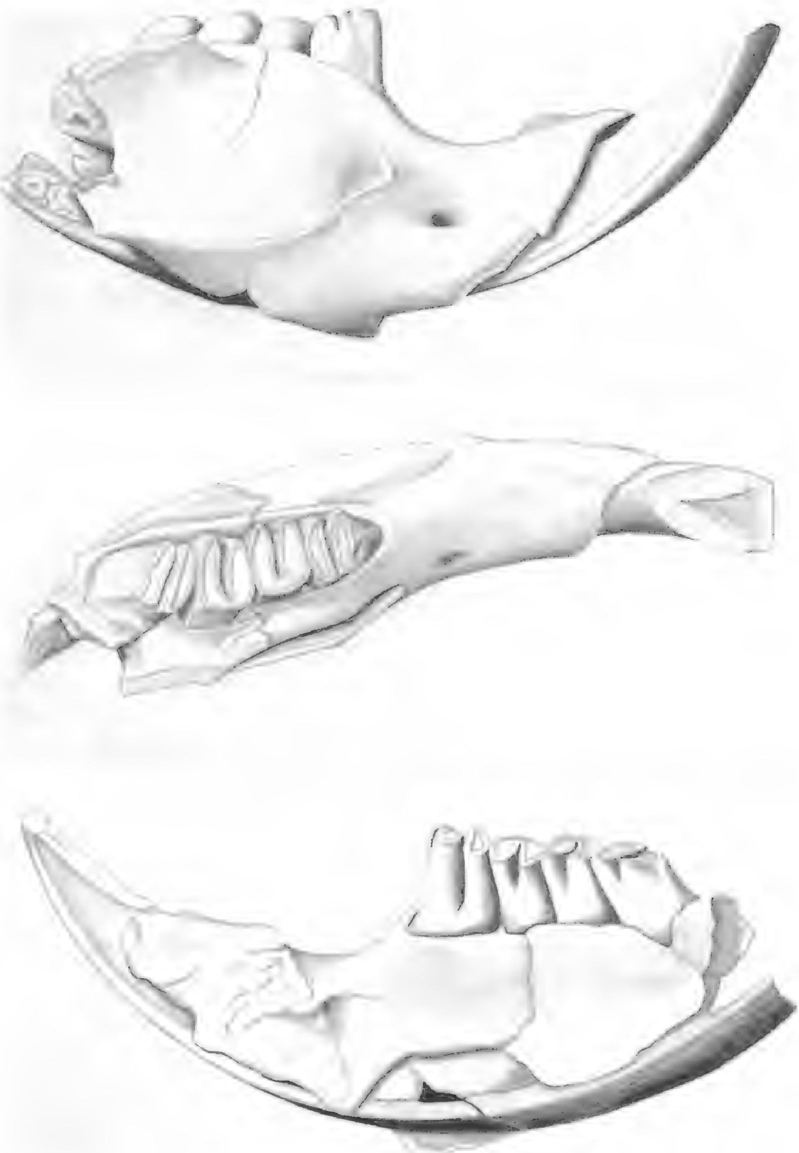


FIG. 10. *Entoptychus* sp., AMNH 56332, right lower jaw with incisor and $P_4$–$M_3$. Top, buccal view; center, occlusal view; bottom, lingual view. All ×4.0.

wall of the anteriormost of the two lophids.

Comparison of the type specimen of *Pleurolicus leptophrys*, AMNH 7174, with AMNH 7185 indicates that the latter, although long referred to *P. leptophrys*, is possibly not conspecific; its upper incisors are only 1.2 mm. wide and lack the medial ridge present in the type, whose upper incisors

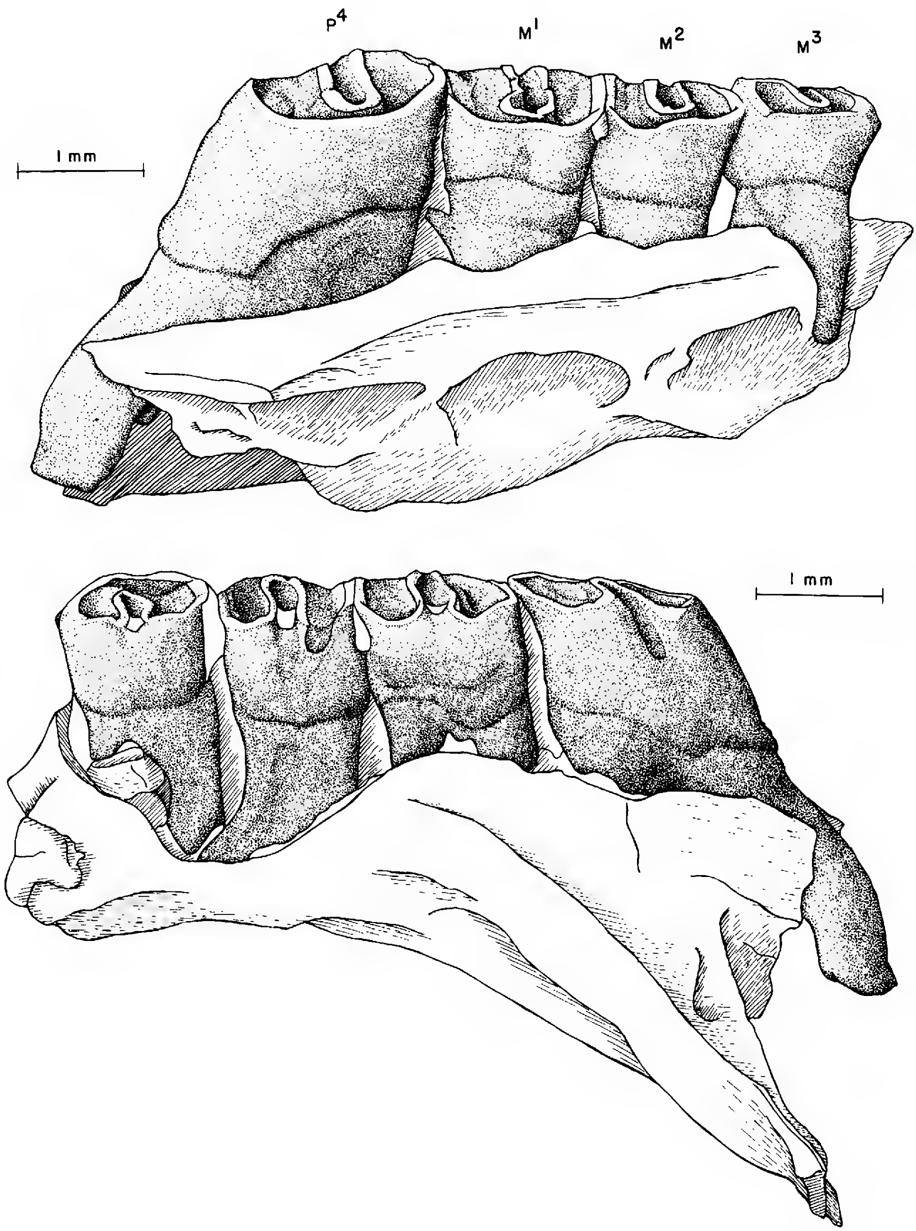



FIG. 11. *Pleurolicus* cf. *P. leptophrys* Cope, 1881, AMNH 56334, left maxillary fragment with $P^4$–$M^3$. Top, lingual oblique view (inverted); bottom, buccal view (inverted). Both ×15.0. See figure 12 for occlusal view.

are 1.8 mm. wide. It is unfortunate that the type specimen is an old individual because the effects of age on incisor width are unknown in these

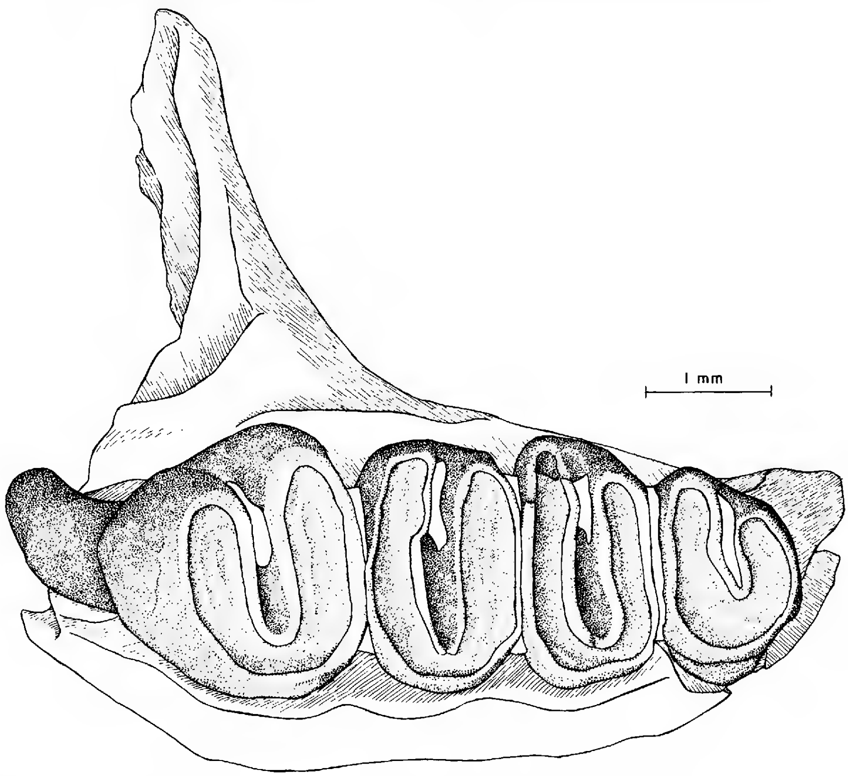



FIG. 12. *Pleurolicus* cf. *P. leptophrys* Cope, 1881, AMNH 56334, left maxillary fragment with $P^4$–$M^3$, occlusal view. ×15.0. See figure 11 for lingual oblique and buccal views.

rodents. Study of a large series from carefully controlled stratigraphic levels can be expected to shed light on this question and such a study is currently being undertaken by John Rensberger of the University of Washington.

Although it is probable that a new species is represented at Darton's Bluff, additional material is necessary before a name should be proposed. The two Darton's Bluff specimens are the smallest entoptychine gophers yet reported and also make the closest approach of any entoptychine to the ancestry of geomyine gophers.

## Unnamed Genus and Species

Figure 14

MATERIAL: AMNH 56335, ?right $P_4$.

COMMENTS: This interesting and enigmatic rodent premolar has been compared extensively with castorid, mylagaulid, and geomyid premolars

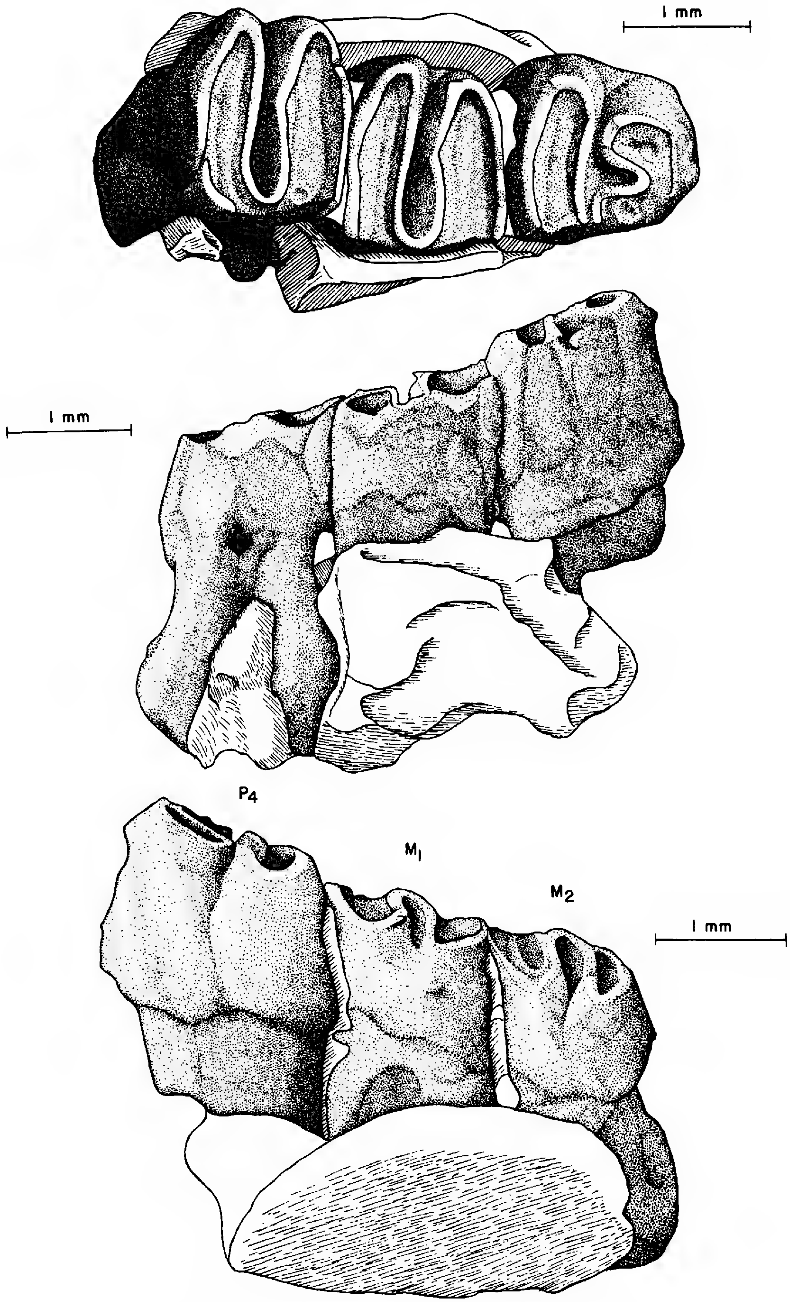



FIG. 13. *Pleurolicus* cf. *P. leptophrys* Cope, 1881, AMNH 56330, right lower jaw fragment with $P_4$–$M_2$. Top, occlusal view; center, buccal view; bottom, lingual view. All ×15.0.

and is unlike any known premolar of these groups in details regarded here as significant at the generic level. The tooth compares most favorably with right $P_4$s of entoptychine geomyids and is interpreted as such here, but it is about twice the size of known *Entoptychus* premolars. The specimen is inadequate to serve as a type and is deliberately left unnamed.

If correctly identified with regard to affinities and cusp homologies, the tooth differs from $P_4$ of other entoptychine gophers not only because of its large size but also because the anterior cingulum row of cuspules

FIG. 14. Unnamed genus and species, AMNH 56335, ?right $P_4$. Left, occlusal view; center, lingual view; right, buccal view. All ×4.0.

has been raised to form an anterolophid, but the "protoconid" and "unnamed cusp" (*sensu* Wood, 1936, fig. 1) have not fully united and are lower than the raised anterolophid and are just coming into wear.

The tooth crown lengthens from 2.2 mm. at the present level of wear to 4.9 mm. at the alveolus. The "protostylid" has fused with the anterolophid.

## FAMILY MYLAGAULIDAE

### *Promylagaulus riggsi* McGrew, 1941

Figures 15, 16

MATERIAL: AMNH 56333, both lower jaws, lacking right $M_3$.

COMMENTS: Both lower jaws of a single individual with well-worn teeth are at hand. *Promylagaulus* is known from the Marsland Formation (*sensu* Skinner, Skinner, and Gooris, 1968) of South Dakota and Nebraska (Wilson, 1960, p. 55), from the Troublesome Formation at the Granby locality in Middle Park, Colorado (Lewis, 1969, p. B54), and also in the Wounded Knee Monroe Creek fauna of South Dakota (Macdonald, 1963, p. 179; 1970, p. 33).

Because the specimen from Darton's Bluff belongs to an old individual, the dental pattern has been worn from the molars, leaving nearly circular enamel rims that surround dentine cores. The cross-sectional shape is not

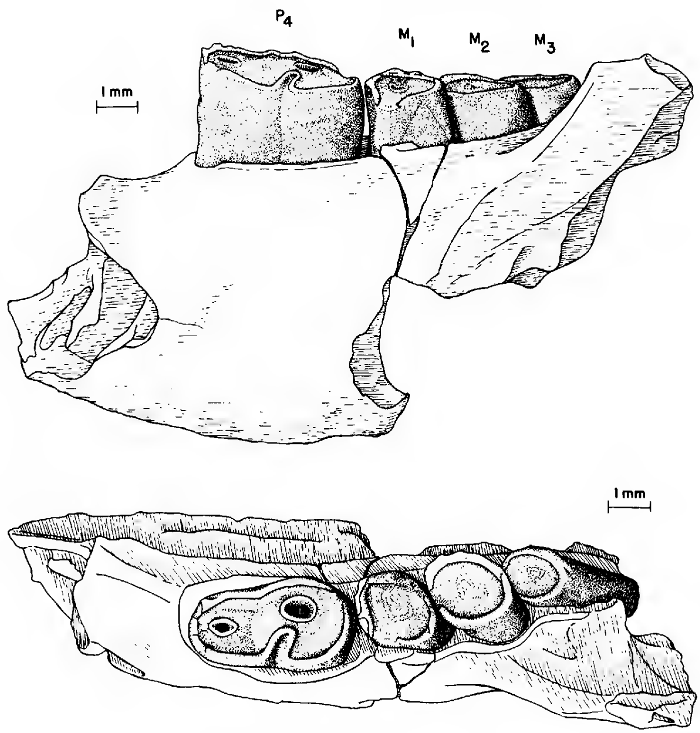



FIG. 15. *Promylagaulus riggsi* McGrew, 1941, AMNH 56333, left lower jaw with broken incisor and $P_4$–$M_3$. Top, buccal view; bottom, occlusal view. Both $\times 5.0$. For right lower jaw of same individual, see figure 16.

elongated anteroposteriorly as it is in the molars of AMNH 10824 from the Marsland, but the latter represents a very young individual. Cross-sectional shape in these teeth changes markedly with wear. On the fourth lower premolar there are only two fossettids and one flexid left at the stage of wear represented. The anterofossettid lies at the anterior end of the tooth and extends at least 1 mm. deeper into the crown; at about the midpoint along the labial wall a protoflexid invades the crown and extends posterolinguad toward the mesofossettid; the mesofossettid is nearly circular and appears to extend at least 1 mm. deeper into the crown. Because of the transparency of the fossilized dentine, features of the nerve canals can be made out, but these are not to be confused with fossettids for they do not reach the occlusal surface.

Measured at the occlusal surface, at the present level of wear, left $P_4$–$M_3$ length is 9 mm. and right $P_4$–$M_2$ length is 7.65 mm.

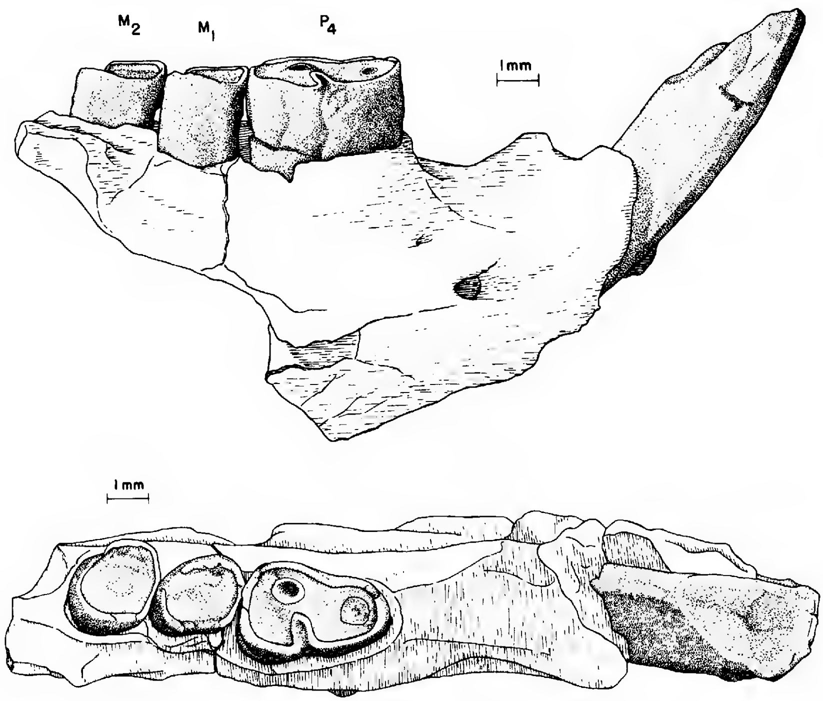



FIG. 16. *Promylagaulus riggsi* McGrew, 1941, AMNH 56333, right lower jaw with incisor and $P_4$–$M_2$. Top, buccal view; bottom, occlusal view. Both ×5.0. For left lower jaw of same individual, see figure 15.

## ORDER ARTIODACTYLA

### FAMILY MERYCOIDODONTIDAE

#### Oreodont cf. *Oreodontoides* sp.

MATERIAL: AMNH 56338.

COMMENTS: A poorly preserved maxilla compares favorably with specimens of the genus *Oreodontoides* from the middle and upper parts of the John Day Formation of Oregon, and from deposits in Washabaugh County, South Dakota, said to be equivalent to the late Arikareean Harrison Formation, but perhaps earlier in age.

### FAMILY CAMELIDAE

#### **Miotylopus gibbi** (Loomis, 1911), new combination

Figures 17, 18

*Oxydactylus gibbi* LOOMIS, 1911, p. 67.
*Protomeryx leonardi* LOOMIS, 1911, p. 68.

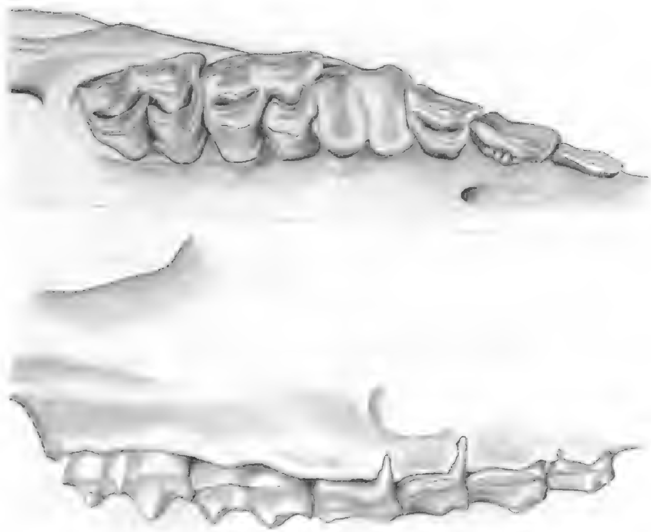


FIG. 17. *Miotylopus gibbi* (Loomis, 1911), AMNH 56337, right maxilla with $P^2$–$M^3$. Top, occlusal view; bottom, buccal view. Both ×1.0. For mandible of same individual, see figure 18.

*Miotylopus brachygnathus* SCHLAIKJER, 1935, p. 174.
Camelidae, subfamily indet.: SKINNER, SKINNER, AND GOORIS, 1968, p. 426.
"Specimen referable to '*Protomeryx leonardi*'": *Ibid.*, p. 429.
Camelidae, gen. et sp. indet.: STEVENS, STEVENS, AND DAWSON, 1969, p. 37.

MATERIAL: AMNH 56337, right maxilla of a female with $P^2$–$M^3$ and associated right and left mandibular rami with all teeth except $I_1$ and $I_2$. Right $dP_2$ has been retained next to right $P_2$ despite the mature condition of this individual.

COMMENTS: *Miotylopus*, a small and primitive *Oxydactylus*-like camel with reduced premolars, was first made known by Loomis (1911), who named new species of *Oxydactylus* and *Protomeryx*, *O. gibbi* and *P. leonardi*, on the basis of two Arikareean specimens. Loomis believed that his specimens had been recovered from Marsland (= "Upper Harrison Formation") sediments stratigraphically above the Harrison Formation, but later work has made it increasingly clear that the type specimens of both *Oxydactylus gibbi* and *Protomeryx leonardi* came from beneath the Harrison Formation. In the Frick Collection at the American Museum of Natural History most specimens of *Miotylopus*, to which Loomis's species are here referred, are from beneath the Harrison Formation in early Arikareean sediments in the Muddy Creek and Little Muddy Creek area south of Lusk, Wyoming and in southern Sioux County, Nebraska (Skinner,

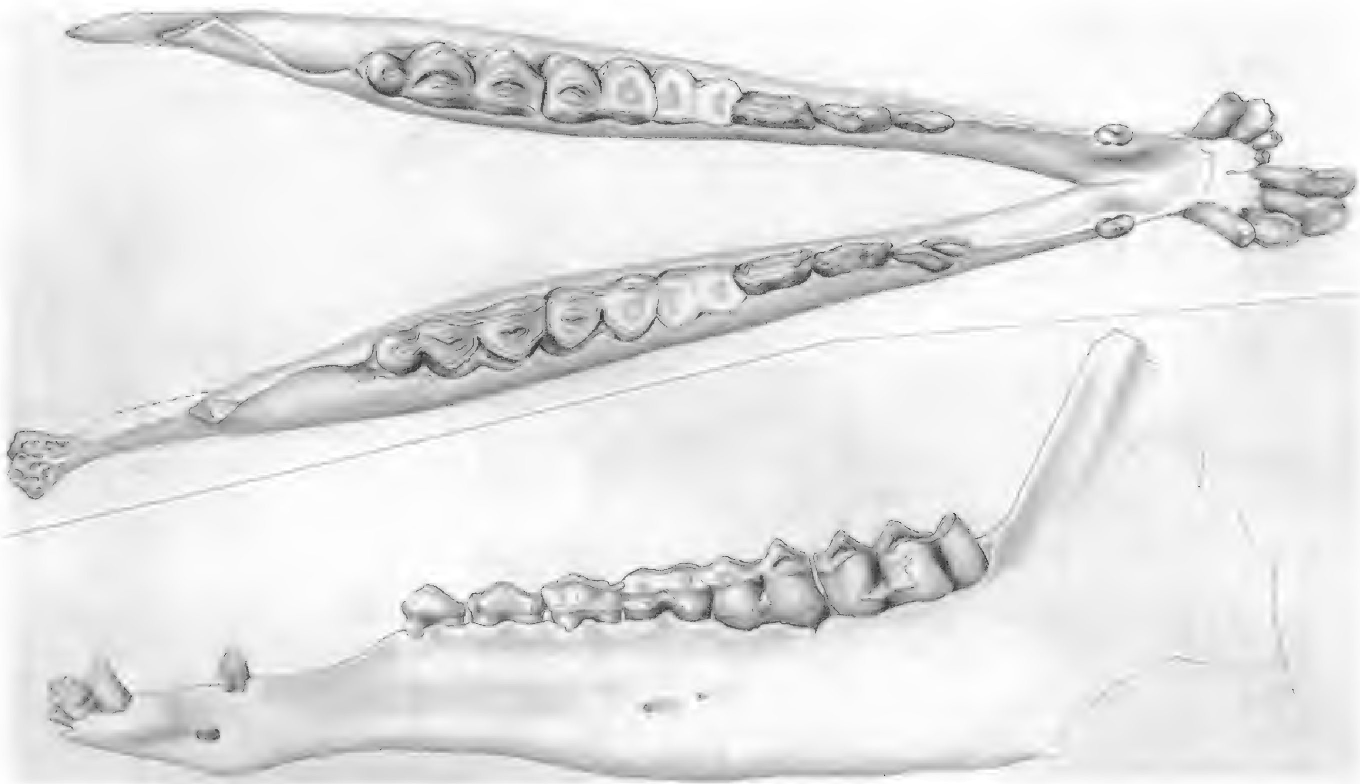


FIG. 18. *Miotylopus gibbi* (Loomis, 1911), AMNH 56337, mandible. Top, occlusal view; bottom, buccal view of left ramus. Both ×1.0. For maxilla of same individual, see figure 17.

TABLE 1

MEASUREMENTS (IN MILLIMETERS) OF SELECTED SPECIMENS OF *Miotylopus*

| | AC 2004[a] | AMNH 56337[b] | MCZ 2924[c] | YPM 10328[d] |
|---|---|---|---|---|
| $M^1$–$M^3$ length | — | 40.3 | 42.0 | — |
| $P^2$–$P^4$ length | — | 27.5 | — | 29[e] |
| $P^2$–$M^3$ length | — | 65.3 | — | — |
| Diastema $C_1$–$P_1$ | 14[e] | 8.5 | — | 12[e] |
| Diastema $P_1$–$P_2$ | 16.5[f] | 15.7 | 15.4 | 22[e] |
| $P_2$–$P_4$ length | 23[b] | 26.8 | 27.5 | 28[e] |
| $M_1$–$M_3$ length | 45.3 | 43[e] | 48.5 | — |
| $P_2$–$M_3$ length | 68[f] | 70[e] | 75.7 | — |
| Jaw depth under $P_1$ | 12[f] | 13[e] | 18.3 | 20[e] |
| Jaw depth under $M_2$ | 18.5 | 19[e] | 24.5 | 25[e] |

[a] Type of *Protomeryx leonardi.*
[b] Specimen of *Miotylopus gibbi* from Darton's Bluff.
[c] Type of *Miotylopus brachygnathus.*
[d] Type of *Oxydactylus gibbi.*
[e] Approximate.
[f] Estimated.

Skinner, and Gooris, 1968, p. 429).

Schlaikjer (May, 1935) provided a valid generic name for these small *Oxydactylus*-like early Arikareean camels although he named a new species, *Miotylopus brachygnathus*, without comparison with Loomis's material, which is within the range of sexual dimorphism, individual variation, and change of appearance due to wear on the teeth that can be expected in a single species. Schlaikjer's name *Miotylopus* has priority over *Dyseotylopus* Stock, 1935 (June), should the latter ever become a synonym of *Miotylopus* as the result of the collection of additional Sespe material from California that would permit a more complete assessment of the affinities of *Dyseotylopus.* Although Schlaikjer stated that his specimen, MCZ 2924, came from the Harrison Formation of the south side of 66 Mountain, Laramie County, Wyoming, his concept of that rock unit included the Gering and Monroe Creek formations of the area (McKenna, 1966). Whether these rock units are separable on rock-stratigraphic criteria is disputed, but the site on the south side of 66 Mountain from which Schlaikjer's type specimen of *Miotylopus brachygnathus* came is at least as old as the Monroe Creek Formation of other areas to the north and east of 66 Mountain.

In size, AMNH 56337 from Darton's Bluff is one of the smallest speci-

mens of *Miotylopus gibbi* known. It is closely similar to the type specimen of *Protomeryx leonardi*, AC 2004 (table 1), and represents a slightly more advanced stage of wear on the teeth. Both AMNH 56337 and AC 2004 are females, for both have weak premolars and canines and both have shallow jaws, especially anteriorly. Similar material in the Frick Collection from Little Muddy Creek [Gering(?) Formation] is under study by Beryl Taylor.

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